Infant and Pediatric Feedings

FOURTH EDITION

Guidelines for Preparation of Human Milk and Formula in Health Care Facilities

Pediatric Nutrition Dietetic Practice Group

EDITORS

Antoinette Maraglino, MS, RD, CSP, CD-N

Wendy Phillips, MS, RD, LD, FAND, FASPEN

Laura Serke, RD, CSPCC, LD, IBCLC

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Academy of Nutrition and Dietetics
120 S. Riverside Plaza, Suite 2190
Chicago, IL 60606

Infant and Pediatric Feedings: Guidelines for Preparation of Human Milk and Formula in Health Care Facilities, Fourth Edition

ISBN 978-0-88091-297-6 (print)
ISBN 978-0-88091-298-3 (eBook)
ISBN 978-0-88091-299-0 (ePub)
Catalog Number 309626 (print)
Catalog Number 309626e (eBook)

10 9 8 7 6 5 4 3 2 1

For more information on the Academy of Nutrition and Dietetics, visit www.eatright.org.

Library of Congress Cataloging-in-Publication Data
Names: Maraglino, Antoinette editor | Phillips, Wendy (Nutritionist) editor | Serke, Laura editor
Title: Infant and pediatric feedings : guidelines for preparation of human milk and formula in health care facilities / editors, Antoinette Maraglino, MS, RD, CSP, CD-N, Wendy Phillips, MS, RD, LD, FAND, FASPEN, and Laura Serke, RD, CSPCC, LD, IBCLC.
Other titles: Infant feedings
Description: Fourth edition. | Chicago, IL : Academy of Nutrition and Dietetics, [2026] | Revised edition of: Infant feedings : guidelines for preparation of formula and breastmilk in health care facilities / Sandra T. Robbins, editor ; Leila T. Beker, co-editor ; Pediatric Nutrition Practice Group, American Dietetic Association. Chicago : American Dietetic Association, 2004. | Includes bibliographical references and index.
Identifiers: LCCN 2026023392 (print) | LCCN 2026023393 (ebook) | ISBN 9780880912976 print | ISBN 9780880912983 eBook | ISBN 9780880912990 ePub

Subjects: LCSH: Infant formulas--Standards | Breast milk--Collection and preservation--Standards | Infants--Nutrition--Standards | Hospitals--Food service--Standards | LCGFT: Handbooks and manuals
Classification: LCC RJ216 .I4985 2026 (print) | LCC RJ216 (ebook)
LC record available at https://lccn.loc.gov/2026023392
LC ebook record available at https://lccn.loc.gov/2026023393

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Frequently Used Terms/ Abbreviations

AAP	American Academy of Pediatrics
ANTT	aseptic Non-Touch Technique
ART	antiretroviral therapy
ASPEN	American Society for Parenteral and Enteral Nutrition
BPA	bisphenol A
BTF	blenderized tube feeding
BUN	blood urea nitrogen
CCP	critical control point
CDC	Centers for Disease Control and Prevention
CMV	cytomegalovirus
CPOE	computerized provider order entry
DHM	donor human milk
EHR	electronic health record
EN	enteral nutrition
FDA	US Food and Drug Administration
FGI	Facility Guidelines Institute
FIFO	first-in-first-out
FMEA	failure mode and effects analysis
FTE	full-time equivalent
HACCP	hazard analysis and critical control point
HM	human milk
HMA	human milk analyzer
HMBANA	human Milk Banking Association of North America
HMO	human milk oligosaccharide

IBCLC	International Board Certified Lactation Consultant
IV	intravenous
KAP	knowledge, awareness, and practices (model)
LC	lactation consultant
MCT	medium-chain triglyceride
MRSA	methicillin-resistant *Staphylococcus aureus*
NDTR	nutrition and dietetics technician, registered
NEC	necrotizing enterocolitis
NICU	neonatal intensive care unit
NSF	National Sanitation Foundation
P&P	policies and procedures
PDCA	plan-do-check-act
PHI	Protected health information
PICU	pediatric intensive care unit
PPE	patient, product, environment
PPE	personal protective equipment
RDN	registered dietitian nutritionist
RN	registered nurse
RPN	risk priority number
RTF	ready-to-feed (formula)
TJC	The Joint Commission
WIC	Special Supplemental Nutrition Program for Women, Infants, and Children

Contributors

Katherine Bennett, MPH, RD
Clinical Dietitian IV, Rady Children's Health
ORANGE, CA

Martha Betts, RDN
Regional Clinical Nutrition Manager, HCA Reston, Stone Springs Hospitals
FALLS CHURCH, VA

Anna Busenburg, RD, CSP, LD, CLC
Nutrition Science and Health Communications Manager, American Dairy Association Mideast
CINCINNATI, OH

Whitney Canfield, MS, RDN, LD, CSP
NICU Dietitian, Levine Children's Hospital
CHARLOTTE, NC

Lauren Davidheiser, MS, RDN, LDN, IBCLC
Lactation Consultant, Children's Hospital of Philadelphia
PHILADELPHIA, PA

Whitney Duddey, MHA, RD, LD, FAND
Clinical Manager, Nutrition Therapy, Cincinnati Children's Hospital Medical Center
CINCINNATI, OH

Trayce Fields, MEd, RDN, CSP, LD, CLC
Clinical Dietitian III, Dayton Children's Hospital
DAYTON, OH

Christy Figueredo, MS, RD, CSP
Clinical Dietitian, University of Miami Miller School of Medicine
MIAMI, FL

Kirsten Frank, RD, CSPCC, LDN, CNSC, IBCLC
Neonatal Dietitian
WILMINGTON, NC

Rachelle Lessen, MS, RDN, LDN, IBCLC
Lactation Consultant, Children's Hospital of Philadelphia
PHILADELPHIA, PA

Jordan McDonald, MS, RD
Director of Food & Nutrition, Children's Hospital of The King's Daughters
NORFOLK, VA

Tegan Medico, MS, MPH, RDN, CNSC
Clinical Dietitian IV, UVA Health Children's/ Morrison Healthcare
CHARLOTTESVILLE, VA

Stephanie Merlino Barr, PhD, RDN, LD
Neonatal Dietitian, MetroHealth Medical Center
CLEVELAND, OH

Amanda Nederostek, MS, RDN
Director, Nutrition Therapy Services, Phoenix Children's
PHOENIX, AZ

Wendy Phillips, MS, RD, LD, FAND, FASPEN
Regional Vice President, Morrison Healthcare
INDEPENDENCE, OH

Alison Ruffin, MHA, RDN, LD, CLC
Director, Clinical Nutrition and Lactation, Dayton Children's Hospital
DAYTON, OH

Natalie Eubank Schroeder, MBA, RDN, LDN
Director, Clinical Nutrition & Formula Lab, Ann & Robert H. Lurie Children's Hospital of Chicago
CHICAGO, IL

Laura Serke, RD, CSPCC, LD, IBCLC
NICU & Women's Care Dietitian, UofL Health—University of Louisville Hospital
LOUISVILLE, KY

Suzanne L. Smith, MS, RD, LDN, IBCLC
Director of Clinical Business Development, Timeless Medical USA Inc
WILMINGTON, DE
Neonatal Dietitian, Catawba Valley Medical Center
HICKORY, NC

Sara Tutor, MS, RDN, CLC
Director, Nutrition Services, Corewell Health
DEARBORN, MI

Reviewers

Patricia J. Becker, MS, RDN, CSP, FAND, FASPEN
Pediatric Neonatal Nutrition Specialist, Private Practice/KidsRD.com
CINCINNATI, OH

Sarah Bishop, DNP, APRN, CCNS, CIC, FAPIC, NE-BC
Infectious Diseases Advanced Practice Provider, University of Louisville Hospital
LOUISVILLE, KY

Kayla Bridges, DCN, MS, RDN, CNSC, FAND
Medical Educator, Bobbie Baby, Inc.
Registered Dietitian, Nourish Telehealth
ORION, MI

Emily Canata, MS, RD, CLC, MSL-BC
Medical Science Liaison, Prolacta Bioscience
DUARTE, CA

Kelly Green Corkins, MS, RD, LDN, CNSC, FASPEN, FAND
Pediatric Clinical Dietitian III/Dialysis, Le Bonheur Children's Hospital
MEMPHIS, TN

Mark R. Corkins, MD, CNSC, FASPEN, AGAF, FAAP
Professor of Pediatrics, University of Tennessee Health Science Center
MEMPHIS, TN

Shayne Geneva, RDN, LD
Director of Standardization, Morrison Healthcare
CLEVELAND, OH

Kendra Glassman, MPAS, PA-C, MS, RD
Neonatal Physician Assistant, Denver Health
FIRESTONE, CO

Marisa Glucoft, MPH, CIC, HACP, CPHQ
Vice President, Quality Improvement & Patient Safety, Children's Hospital Los Angeles
LOS ANGELES, CA

Shannon K. Goff, MPH, RD-AP, CNSC, CLC
Manager, Clinical Nutrition & Lactation, Children's Hospital Los Angeles
LOS ANGELES, CA

Andie Lee Gonzalez, PhD, MPH, RDN, LD, FAND
Senior Pediatric Medical Science Liaison, Abbott Nutrition
MISSION, TX

Tiffani Hays, MS, RDN, LDN, CSP
Pediatric Nutrition Consultant
BALTIMORE, MD

Bethany S. Hodges, MS, RD, MSL-BC
Medical Science Liaison, Mead Johnson Nutrition
ST. JOSEPH, MI

Valerie Hoehn, RD
Supervisory Dietitian/NICU Dietitian, Naval Medical Center Portsmouth
PORTSMOUTH, VA

Ginevra Janus, MBA, RD, CNSC
Director, Nutritional Services, Loma Linda University Children's Hospital
LOMA LINDA, CA

Crystal Lucas, MS, RD
Director of Food and Nutrition
PORTERVILLE, CA

Melanie Newkirk, DCN, RDN, CSP, LD
Senior Clinical Specialist Manager, Timeless Medical Systems
TAMPA, FL

Maryanne Perrin, PhD, MBA, RDN
Professor, University of North Carolina Greensboro
GREENSBORO, NC

Amy Reed, MS, RD, CSP, LD
Registered Dietitian
CINCINNATI, OH

Hannah Roosevelt, RD
Clinical Nutrition Manager, Seattle Children's Hospital
SEATTLE, WA

Joni Finton Rose, MS, RD, LDN, IBCLC, RLC
Lactation Consultant, Le Bonheur Children's Hospital
MEMPHIS, TN

Hope Severa, MBA, RD, LD
Registered Dietitian Nutritionist
AURORA, OH

Carrie Smith, MS, RD, LD
Clinical Manager, Cincinnati Children's Hospital Medical Center
CINCINNATI, OH

Caroline Steele, MS, RD, IBCLC, FAND
Senior Clinical Consultant, Timeless Medical Systems
NEW PORT RICHEY, FL

Lindsay K. Weir, MPH, CIC, AL-CIP
Infection Prevention Regulatory & Surveillance Specialist, Boston Children's Hospital
BOSTON, MA

Jacqueline Wessel, MEd, RDN, CNSC, CLE
Neonatal Nutritionist, Intestinal Rehabilitation CinCEIR, Cincinnati Children's Hospital
CINCINNATI, OH

Foreword

Nutrition is essential for health, and this is especially true for children, whose nutritional needs exceed those of adults because of their rapid growth and development. Ideally, human milk and/or, when needed, infant formula serve as the sole sources of nutrition early in life. Even after complementary foods are introduced, human milk or formula remain key contributors to a child's nutritional intake for a significant period of time.

The potential consequences of errors in the storage, preparation, handling, or administration of human milk or formula are serious and may include inadequate growth and development, illness, injury, or even death. This risk is especially pronounced in hospitals and other health care settings, where patients are often premature or have acute or chronic illnesses that increase their susceptibility to infection and other adverse events. For this reason, this book focuses on infant and pediatric feedings within health care facilities—though the principles and practices it presents are also relevant to outpatient and home settings. Each chapter offers guidance on safety and best practices for managing these vital sources of nutrition. Given the potential for microbial contamination and allergen cross-contact, meticulous adherence to proven handling and preparation methods is critical. The recommendations provided in this book minimize these risks while helping ensure that the nutrition delivered matches the carefully calculated needs of each infant.

This book is designed to be highly practical, offering guidance on everything from the physical layout of preparation rooms to the development of protocols for emergency situations. It places the collective experiences of leading infant nutrition experts into your hands, helping you implement evidence-based practices efficiently and safely—without delays in care or preventable errors that can compromise outcomes.

The fourth edition of *Infant and Pediatric Feedings* supports the delivery of efficient, safe, and effective nutrition care across health care settings. It is intended to complement other clinical nutrition resources that address assessment and prescription of nutrition in pediatric populations, providing the next step in the process: practical guidance for operationalizing nutrition care—from the point of order entry to the moment the feeding reaches the patient.

Mark R. Corkins, MD, CNSC, FASPEN, AGAF, FAAP
St Jude Chair of Excellence in Pediatric Gastroenterology
Professor of Pediatrics, University of Tennessee Health Science Center
Division Chief of Pediatric Gastroenterology, Hepatology and Nutrition,
Le Bonheur Children's Hospital

Preface

It may seem unusual that a reference book can be endeared to so many, but this is one such case. Every time the book *Infant and Pediatric Feedings: Guidelines for Preparation of Human Milk and Formula in Health Care Facilities* is mentioned, people ask, "When is the next edition coming out?" However, this latest edition would not have been possible without the work that preceded it and the tireless efforts of the original concept visionaries. This fourth edition is actually the fifth publication in a series on this topic written by the members of Pediatric Nutrition Dietetic Practice Group (PNPG) of the Academy of Nutrition and Dietetics.

The first publication in the series came out in 1991, titled *Preparation of Formula for Infants: Guidelines for Health Care Facilities*. That publication resulted from a project codirected by Diane M. Anderson and Linda J. Boyne, with partial support from MCJ 176020 through the Maternal and Child Health Services Block Grant Program (Title V, Social Security Act), administered by the Health Resources and Services Administration, Department of Health and Human Services. The manual was the first of its kind and the result of collaboration between PNPG and many multidisciplinary professional organizations.

In 2004, PNPG developed the first edition of *Infant Feedings: Guidelines for Preparation of Human Milk and Formula in Health Care Facilities*. Editors Sandra T. Robbins and Leila Beker led a group of clinically experienced authors in expanding the original concept of the 1991 publication to include the handling of human milk. The first edition was supported in part by grant funding from the Maternal and Child Health Bureau (grant 5 T79 MC 00023-03), the Health Resources and Services Administration, and Cincinnati Children's Hospital.

Editors Sandra T. Robbins and Robin Meyers directed the publication of the second edition in 2011, which expanded further on the topics previously covered and provided guidance on new areas such as the handling of pasteurized donor human milk, the use of sterile liquids over powdered formulas, and recommendations for probiotic-containing formulas. Commonly referred to as simply the "green book," the second edition was widely cited as the definitive authority on human milk and formula handling within the health care setting and was widely used by both clinicians and surveyors alike.

For the 2019 third edition, Sandra Robbins and Robin Meyers passed the editor batons to Emily A. Collins and myself but, thankfully, stayed on as authors to lend their expertise and support. Frequently referred to as the "blue book," this edition nearly doubled the content from the second edition, adding new chapters with recommendations on centralized feeding preparation, lactoengineering, pasteurized donor human milk, blenderized

tube feedings, and the use of modulars and additives. This edition was recognized by the Association of Marketing and Communication Professionals, receiving their Platinum Hermes Creative Award in the print media/book category.

In 2024, Wendy Phillips, Laura Serke, and Antoinette Maraglino answered the call to serve as editors. True to form, this project is not one that rests on its laurels. This fourth edition continues the trend of expanding content based on new information and research as is outlined in the Exploring the Fourth Edition section.

As someone who uses this resource on a regular basis, I am grateful for the hard work and dedication of all the authors and reviewers, without whom this publication would not have been possible. As an author for the second edition, coeditor for the third edition, and reviewer for the fourth edition, I know how much time and effort goes into making this book the premier, sought-after reference that it is. It is an honor to be part of a project with such a distinguished history and rich background of collaboration. My gratitude goes out to the authors, reviewers, and advisors of this edition as well as those involved with the previous publications in this series who have led this project to where it is today. Like many clinicians across the country, I am anxiously waiting to receive my copy of the fourth edition. I have no doubt it will be well-worn and dog-eared in short order—a true testament to its value as the premier resource for the safe and accurate handling of infant and pediatric feedings.

Caroline Steele, MS, RD, IBCLC, FAND

Acknowledgments

We would like to express our deepest appreciation to the authors and reviewers who contributed to the fourth edition of *Infant and Pediatric Feedings*. Your expertise, thoughtful perspectives, and dedication to advancing pediatric nutrition have been essential in moving this edition forward. We are grateful to the Pediatric Nutrition Dietetic Practice Group (PNPG) members who encouraged the development of this new edition and shared thoughtful recommendations for the information most needed in practice. We would also like to thank the PNPG publications committee and the Academy of Nutrition and Dietetics publications team for their professional guidance, coordination, and support throughout the revision process.

We extend special recognition to the editors, authors, and contributors of earlier editions whose vision and dedication laid the foundation for this book. Each new edition builds on their work, and their contributions continue to inspire and guide the integration of new content as clinical practices evolve.

The strength of this publication lies not only in those who create it, but also in those who bring the principles to life in practice. We hope this book will continue to serve as a valuable resource to advance nutrition care for infants, children, and families in health care settings. We also encourage readers to consider contributing their unique expertise to future editions.

As editors, we are honored to be part of this ongoing endeavor. The fourth edition of *Infant and Pediatric Feedings* reflects the collective experience and dedication of our profession, and it is through these shared efforts that the field of pediatric nutrition continues to advance. We look forward to seeing this publication continue to evolve in the years ahead, strengthened by the ongoing collaboration of our colleagues.

Antoinette Maraglino, MS, RD, CSP, CD-N
Wendy Phillips, MS, RD, LD, FAND, FASPEN
Laura Serke, RD, CSPCC, LD, IBCLC

About the Editors

Antoinette (Toni) Maraglino, MS, RD, CSP, CD-N

Antoinette (Toni) Maraglino is a registered dietitian and certified dietitian nutritionist with a master's degree in nutrition science from the Friedman School of Nutrition Science and Policy at Tufts University. She has over 16 years of experience in dietetics with expertise in pediatric and neonatal nutrition as well as clinical nutrition and operations management. Toni is currently the Senior Manager of Clinical Nutrition, Laboratory Services, and Point of Care Testing at Connecticut Children's Medical Center. She began her career as a neonatal dietitian, working at Johns Hopkins Children's Center, Floating Hospital for Children at Tufts Medical Center, and Children's Hospital of Philadelphia (CHOP). In 2019, she became Manager of Enteral Feeding Preparation at CHOP, and in July 2021 she was appointed Clinical Nutrition Manager at Dartmouth-Hitchcock Medical Center.

Toni collaborated with America's Test Kitchen and served as the pediatric nutrition content expert for *The Complete Baby and Toddler Cookbook*. She has also consulted with hospitals on milk room design and operations. Toni is involved in promoting the dietetics profession through her involvement in the Academy of Nutrition and Dietetics' Pediatric Nutrition Dietetic Practice Group (PNPG), Clinical Nutrition Management dietetic practice group (CNM DPG), and the Friedman School Alumni Association Executive Council (AAEC). She has served as editor of *Building Block for Life*, as well as Secretary and Chair of PNPG. She is currently Chair of the CNM DPG Nominating Committee. In addition, Toni has held roles as Mentoring Committee Chair, Awards Committee Chair, Secretary, and she now serves as President of the Friedman School AAEC. She has authored multiple peer-reviewed articles and book chapters on neonatal nutrition and has presented nationally on neonatal nutrition and pediatric nutrition calculations.

As a newborn in the mid-1980s, Toni spent a stint in the NICU and was fed an exclusive diet of soy formula, which was very on-trend for the times. She is thrilled to be providing guidance on how to safely provide feedings to NICU infants as well as all other hospitalized children. In her spare time, Toni enjoys traveling, cooking, and yoga and is a RYT 200. She lives in Connecticut with her wife and 2 rescue pups.

Wendy Phillips, MS, RD, LD, FAND, FASPEN

Wendy Phillips holds a master's degree in clinical nutrition and brings 25 years of experience in adult and neonatal nutrition support, critical care, public health, diabetes management, nutrition policy advocacy at the state and national levels, and clinical nutrition as well as executive leadership. She has been credentialed as a certified nutrition support clinician, certified lactation educator, and nutrition wound care clinician, and is a Fellow of both the Academy of Nutrition and Dietetics (the Academy) and the American Society for Parenteral and Enteral Nutrition (ASPEN). She has authored over 85 peer-reviewed articles and spoken nationally on topics such as malnutrition, food security and population health, order writing privileges for registered dietitians, and nutrition policy and advocacy.

Wendy has worked for Morrison Healthcare since 2009, first in clinical nutrition leadership roles, and currently as a Regional Vice President. She has served in state affiliate leadership positions in Virginia, Utah, and now Ohio, and has held national leadership roles for ASPEN and the Academy. Academy leadership roles include positions in the Clinical Nutrition Management dietetic practice group, Dietitians in Nutrition Support dietetic practice group, and the Pediatric Nutrition Dietetic Practice Group (PNPG). For PNPG, she has served as an associate editor for *Building Block for Life* and as a member of the Malnutrition Committee. Amongst many national awards, she received a Medallion Award from the Academy in 2023.

One of her 2 sons (who are now adults) is a NICU graduate whose stay was complicated by preventable nursing inaccuracies related to breastfeeding and breastmilk misadministration. Wendy is therefore passionate about providing accurate and practical information to prevent similar occurrences for other families. Thankfully, that NICU graduate is now 6'3" tall and a thriving young adult who is about to graduate with honors with a biology degree!

Laura Serke, RD, CSPCC, LD, IBCLC

Laura Serke graduated from the University of Kentucky with a dual degree in nutrition and exercise science. She is a registered dietitian, certified specialist in pediatric critical care nutrition, and international board certified lactation consultant with 20 years of experience in clinical nutrition. Laura currently works in the Level III NICU and Women's Care Unit at the University of Louisville Hospital, a Baby-Friendly designated facility.

While the hospital already had an established infant feeding preparation room, Laura contributed to the continued expansion of the program. Her clinical projects resulted in improvements in the handling of fresh and frozen milk, measurement of osmolality in fortified feedings, utilization of heated water for powder infant formula preparation, and upgrades to equipment for refrigeration, freezing, and thawing.

Laura is passionate about using human milk analysis to empower parents and guide individualized fortification. Drawing on her research experience, she led the implementation of human milk analysis in the NICU. Her focus has shifted to the proactive analysis of fresh milk in real time to highlight the value of early milk and, when needed, provide feedback that helps parents improve the caloric content of their milk for their baby.

Laura's training in foodservice and ServSafe certifications continue to be relevant in the NICU as the cornerstone of safe infant feedings. An early study on extended storage of fresh milk led to the discovery of bacterial contamination and sepsis in preterm infants due to improperly washed pump parts, shaping her lifelong commitment to infection prevention and safe milk handling. She later coauthored the Microbiology and Infection Control chapter in the third edition of *Infant and Pediatric Feedings*.

Laura remains active in subject-matter expert projects and speaking on a national level. She received a Bell Award in 2024 for her volunteer work with assistance dogs in training.

New and Noteworthy: Exploring the Fourth Edition

Proper preparation of human milk (HM) and infant formula is essential to prevent foodborne illness and feeding errors, and to ensure that infants receive the correct products in the appropriate concentrations to support growth and development. Providing the right product to the right patient at the right time is critical.

This publication offers guidance for the safe handling of HM and formula in health care facilities. With few exceptions, HM remains the preferred feeding for infants, including those who are premature or hospitalized. Centralized handling of HM and formula in a designated preparation space is well supported by the literature and recognized as best practice. Acknowledging that some facilities may lack the space or resources for a centralized feeding preparation room, this book also provides guidance for making the case for such a model, and for developing and implementing a project plan to move toward centralized handling.

The fourth edition of *Infant and Pediatric Feedings* was developed throughout 2024 and 2025 by an esteemed group of registered dietitian nutritionists (RDNs) and international board certified lactation consultants (IBCLCs). Suggestions for updated and new content were submitted to the editors through multiple channels, and most of these contributions have been incorporated into this edition. Some topics, however, were not included because they fell outside of the scope of the book, the research is evolving too rapidly and could become outdated before the next edition, or the current evidence base is insufficient to support clear guidance.

Similar to previous editions, a thorough review of the literature was conducted, and best practices from centralized infant feeding preparation rooms across the country have been incorporated. The Guidelines section from the third edition has been integrated into relevant chapters and the Table of Contents has been expanded to provide greater detail. Each chapter reinforces key handling practices, while the primary chapter for each topic offers the most comprehensive review of that subject. Contributors from a variety of disciplines, clinical settings, and industry provided valuable insights and peer review for individual chapters.

BUILDING AN INCLUSIVE CULTURE

The authors, reviewers, and editors are committed to fostering an inclusive culture, and these principles are reflected throughout the book. Many chapters incorporate inclusive concepts within their content, and some include dedicated sections (titled "Building an Inclusive Culture") addressing topics of particular significance or those commonly encountered in practice. In an effort to use inclusive terminology, the following choices were made:

- **Parent** instead of *mother*.
- **Human milk** instead of *breast milk*.
- While *breastfeeding* and *breast pump* remain the terms most commonly used by major national and international organizations such as the American Academy of Pediatrics (AAP), American College of Obstetricians & Gynecologists (ACOG), Human Milk Banking Association of North America (HMBANA), La Leche League International, and the World Health Organization (WHO), among others, the lactation chapter (Chapter 7) discusses use of the term **chestfeeding**, which is becoming more widely used as of the publication of this edition.

NEW TO THIS EDITION

Since the third edition was published 7 years ago, several new topics and concepts have emerged that deserve particular attention here. Items specific to the fourth edition include the following:

- **Refrigeration temperatures** were reviewed and updated. Due to rounding between Celsius and Fahrenheit, the upper limit for safe refrigerator storage is cited as either 39 °F (4 °C) or 40 °F (4.4 °C) by various references, publications, and health care facilities. This variation may also impact the challenge of finding refrigeration equipment that can maintain such a tight temperature gradient, as medical-grade refrigerators are typically designed for pharmacy or laboratory use. For consistency throughout this text, we have chosen 40 °F (4.4 °C) as the upper limit of the safe temperature range for storing HM and formula.
    - The one exception is **blenderized feedings**, for which the maximum cold storage temperature is 41 °F (5 °C), consistent with the US Food Code. This higher limit applies because whole foods are used to make these types of feedings, and preparation may occur in a foodservice kitchen that follows Food Code standards. While colder holding temperatures—without freezing—are ideal, these temperatures represent the maximum recommended holding temperatures.

- The **microbiology chapter** from the third edition has been interwoven into relevant chapters throughout this edition to provide a more seamless presentation of related content.
- **Electronic health records (EHRs)** are now widely used across nearly all health care facilities, prompting the need to develop electronic workflows and EHR order structures that promote accuracy and efficiency in feeding preparation operations. This edition offers recommendations to support these efforts. In addition, as **cybersecurity threats** become more prevalent, strategies for mitigating these risks are addressed in the emergency preparedness chapter (Chapter 14).
- The aftermath of the **COVID-19 pandemic** led to a heightened focus on hygiene and greater interest in understanding disease transmission. These topics are addressed within relevant chapters.
- **Formula recalls and back orders, donor milk shortages, and supply chain disruptions** have increased in scale, frequency, and impact. Consequently, imported infant formulas are now more widely used in the US marketplace than in previous years. Best practices for management and risk mitigation related to these issues are included in this edition.
- For the first time in over 25 years, the federal government embarked on an initiative to review infant formula safety, composition, and availability. Although this work is ongoing, the most current information available at the time of publication is summarized in Chapter 10.

ORGANIZATION OF THE FOURTH EDITION

This edition is organized into 14 chapters, with each providing detailed guidance on a specific aspect of infant and pediatric feeding preparation in health care facilities. Many chapters include sample documents and resources to assist facilities in developing their own processes, policies, and procedures.

- **Chapter 1—The "Why"** is a new introduction that engages readers in understanding the importance of safely handling HM, formula, additives, and water used in feeding preparation. It highlights the many potential points of failure and provides a framework of fundamental food handling principles, along with strategies for implementing practice changes that promote a strong culture of food safety in pediatric acute care settings.
- **Chapter 2—Centralization** acknowledges the spectrum of preparation spaces, ranging from noncentralized to fully centralized models, with the goal of advancing

practice toward greater centralization of space and processes. Readers can use the resources provided to analyze their current feeding preparation practices—including regulatory considerations—and compare them to a desired future state. The chapter also outlines best practices for developing a project plan and addressing key logistics, such as departmental oversight, workflow design, and space allocation.

- **Chapter 3—Facilities** addresses the physical space and infrastructure needed to support a safe and efficient infant and pediatric feeding preparation. **Chapter 4—Equipment** provides guidance on selecting and maintaining appropriate equipment and supplies, ranging from large freezers to single-use items used during feeding preparation and handling. **Chapter 5—Management** outlines principles for staffing and workflow management to meet the needs of multiple stakeholders throughout the hospital, ensuring safe and timely service for infants and children. Sample job descriptions, workflow designs, competency assessments, documentation tools, and other practical resources are included.
- Safe food handling, preparation, and administration techniques apply equally to both formula and HM products. **Chapter 6—Handling** provides guidance on managing feeding orders and recipes, along with packaging and labeling considerations for workflows within a centralized feeding preparation room. It also offers recommendations for product delivery and storage on patient units, as well as information on administration and infection control. To support continuity of care, the chapter includes best practices for after-hours procedures when the feeding preparation room is closed and discusses key considerations for patient discharge.
- The book then shifts to focus on the various pediatric feeding options. **Chapter 7—Lactation** reviews strategies for supporting the initiation and maintenance of milk supply, including guidance on pumping, handling and transport of HM, as well as considerations related to disease transmission during illness, misadministration, or informal milk sharing. **Chapter 8—Donor Milk** discusses formal HM sharing, from donor screening and processing methods to the ethical and cultural considerations surrounding the use of donor milk. **Chapter 9—Lactoengineering** provides comprehensive information on the nutritional composition of HM and its implications for fortification, analysis, and skimming.
- When HM is not available or appropriate, alternative forms of nutrition must be used. **Chapter 10—Formula** and **Chapter 11—Blenderized Feedings** address these topics. They review product selection, order and recipe development, and other key considerations, along with governmental and professional organizational

guidelines for formula management. **Chapter 12—Additives** covers the use of modulars and medications that may be indicated and administered with either HM or formula to promote growth and healing.

- As with any process or procedure that carries potential risk, it is essential to maintain a robust quality assurance and outcomes measurement framework to ensure safe, efficient, and effective care. **Chapter 13—Quality Assurance** provides examples of quality improvement evaluations and documentation, along with guidance on conducting a thorough risk factor analysis.
- The book concludes with **Chapter 14—Emergency Preparedness,** which provides guidance for advance planning in the event of technology interruptions, natural disasters, product recalls, shortages, and other disruptions that may affect safe and consistent feeding operations.

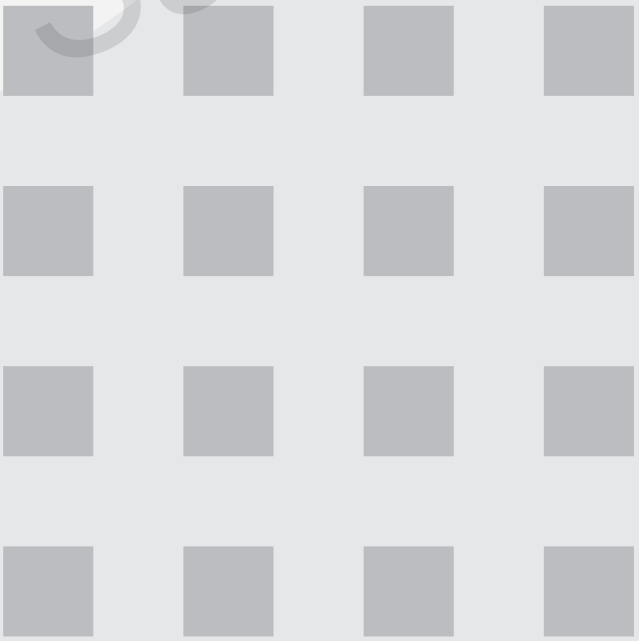
PRACTICAL APPLICATIONS

Throughout the book, there is an emphasis on regulatory considerations to help ensure that centralized feeding preparation spaces meet local, state, and federal inspection requirements, including those from the Centers for Medicare & Medicaid Services (CMS) and accrediting agencies. In areas where no regulatory requirements or published research exists to guide operations, best practices and examples from successful health care facilities are provided.

The content in this edition should not be interpreted as regulation unless specifically identified as such. The recommendations presented are best-practice guidelines informed by the research and scientific evidence available at the time of publication. In the absence of pediatric-specific studies, information from both the infant and adult literature—as well as expert consensus—has been included and extrapolated to pediatric care.

Redundancy within this edition is intentional to emphasize key concepts and reinforce critical safety principles. The overarching goal of this publication is to provide facilities with practical, evidence-based guidelines to ensure that infants and children receiving HM, formula, blenderized feedings, and modulars or additives in the health care setting are supported with feedings that are prepared in the safest manner possible.

As new research and outcomes data continue to emerge, readers are encouraged to consult additional resources to remain current and further inform their practice with infants and children.



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The "Why" (Culture of Food Safety)

Laura Serke, RD, CSPCC, LD, IBCLC, and
Anna Busenburg, RD, CSP, LD, CLC

INTRODUCTION

It is essential for any operation responsible for preparing and serving food to establish clear guidelines and consistent practices around food safety. In health care facilities, food safety is primarily associated with the foodservice department; however, it also applies to spaces for infant and pediatric feeding preparation. Food safety must remain a consistent focus, applied not only during everyday operations but also in times of disruption or transition. Imagine a day when your usual preparation space or workflow is suddenly compromised—the kitchen is hit with a leak, a freezer fails, staff are running short, the census surges, or a key product is on back order. How do you *maintain* food safety practices in a makeshift area, with different products, fewer staff, or increased demands? Alternately, imagine that your usual workspace or process is going to be improved—a renovation is finalized, a human milk (HM) analyzer is installed, technician staffing increases, donor human milk (DHM) is added, or a move toward unit-dosed preparation occurs. How do you *expand* food safety practices in these evolving areas?

This chapter will review the multitude of food safety failure points unique to the pediatric health care setting and present strategies to address them. The ideas presented in this chapter will be carried over and expanded throughout the rest of this book. Understanding risk (using the Patient Product Environment framework) and applying best practices (using the Knowledge Awareness Practice model) support consistent application of food safety principles across a variety of care environments.

THE RESTAURANT PERSPECTIVE

Have you ever considered pediatric feeding preparation spaces as foodservice operations? While a health care setting is far from the ambiance of a quaint café or fine-dining experience, the scale of food preparation is not so different. This is especially true when you consider that health care facilities operate 365 days per year and infants require an average of 8 "meals" per day. Consider the following[1,2]:

- A small restaurant (<50 seats) may serve 50 to 150 meals per day, with a limited menu and small staff. This amounts to 18,000 to 55,000 meals per year, which is equivalent to serving 6 to 18 infants per day.
- A medium restaurant (50-100 seats) may serve 150 to 500 meals per day, with a larger menu and staff. This results in 55,000 to 180,000 meals per year, equivalent to serving 18 to 62 infants per day.
- A large restaurant (>100 seats) may serve 500 to 1,200 meals per day, with a diverse menu and extended hours. This is equivalent to 180,000 to 435,000 meals per year, comparable to serving 62 to 150 infants per day.

From this perspective, both stand-alone pediatric units and full children's hospitals can be viewed as high-volume foodservice operations, where attention to food safety plays a critical role in overall patient safety. Figure 1.1 illustrates how feeding preparation spaces compare to restaurant operations in terms of meal volume, staffing, and menu

Figure 1.1 From cafés to care units: how pediatric feeding preparation spaces compare to restaurant operations[1,2]

	HOME COOKING	SMALL RESTAURANT	MEDIUM RESTAURANT	LARGE RESTAURANT
Seating capacity	2-3 people	<50 seats	50-100 seats	>100 seats
Serving capacity	8 meals per day 3,000 per year	50-150 meals per day 18,000-55,000 per year	150-500 meals per day 55,000-180,000 per year	500-1,200 meals per day 180,000-435,000 per year
Menu	Limited	Limited	Larger	Most diverse
Staffing	Limited	Smaller	Larger	Extended hours
NICU equivalent (8 feedings per infant per day)	1 infant per day	6-18 infants per day	18-62 infants per day	62-15 infants per day

Abbreviation: NICU, neonatal intensive care unit

complexity.[1,2] Recognizing this scale reinforces the need to systematically identify and address food safety risks unique to pediatric health care environments.

PATIENT PRODUCT ENVIRONMENT FRAMEWORK FOR IDENTIFYING FOOD SAFETY RISK

Personal protective equipment (PPE) is a well-established tool in health care, used to protect both patients and staff from infectious agents. The concept of PPE can extend beyond simply wearing gloves, masks, or gowns and represents an overarching strategy to mitigate risk across different situations.[3] Just as you integrate PPE into clinical practice, you can repurpose the same acronym to systematically identify food safety risks in pediatric feeding preparation spaces. In this context, PPE can be used to represent the patient (P), product (P), and environment (E). The PPE framework serves as a tool for identifying food safety risk and translates the concepts presented in this book into real-life pediatric feeding preparation scenarios in health care settings.

Patient (P) Risk

The patient is at the center of the PPE framework. Pediatric feeding preparation spaces have traditionally been associated with preparing food for infants who are at high risk for feeding complications (including those born preterm, those with low birth weight, those who are immunocompromised, or those aged <2-3 months)[4,5] and are often tied to neonatal intensive care units (NICUs). These spaces, however, may also be used to prepare specialized feedings for patients on pediatric floors or in pediatric intensive care units (PICUs). Some patients require individualized precautions for food allergies or dysphagia, where errors in feeding preparation can result in serious adverse events such as anaphylaxis or aspiration. In addition, during periods of acute illness, pediatric patients are at increased risk for infection and metabolic complications, both of which can be exacerbated by improper handling, mixing, or administration of feedings.

Beyond medical vulnerabilities, accurate patient identification during the delivery and administration of feedings represents a significant safety concern.[6] In NICUs, similar dates of birth, sequential medical record numbers, or discrepancies in assigned names (eg, using "Baby" as a first name or planning to use a different last name) increases the chance of misidentification errors. This misidentification risk further increases with the delivery of multiple infants (twins, triplets, etc) listed with the same information or use of a gestational carrier with a different intended last name. Because feeding preparation involves delicate patients and complex workflows, accurate patient identification is an essential component of safe food handling in pediatric care. Robust identification and verification processes are critical to protect against misadministration errors that could lead to medical harm.

Personal preference is another important consideration of patient- and family-centered care. Patients from different religious and cultural backgrounds may request unique products or preparation methods to meet their nutrition needs in a way that respectfully aligns with their beliefs. Meeting diverse needs involves careful integration of individualized feeding practices with standardized food safety practices.

Maintaining a focus on patient-specific risks and needs is essential at every feeding preparation step to ensure patient safety. While a health care worker may concentrate on a

single patient at a time, feeding preparation spaces support the needs of multiple patients simultaneously, and workers in these areas must pay meticulous attention to detail.

Product (P) Risk

The second P in the PPE framework focuses on products and maintaining *internal integrity* through appropriate holding practices. Among the factors that promote microbial growth, time and temperature exposure are primary contributors and are the main focus of this section. Feeding products inherently contain several properties that support microbial growth and spoilage, including the presence of food (nutrients for fuel), acidity (neutral to slightly acidic), oxygen (air exposure), and moisture.[7] In the NICU, staff handle products such as parent's expressed HM, DHM, and infant formula. For older pediatric patients, specialized formulas, modular additives, and nutrition supplements may be used. The same principles of safe handling apply across all settings to ensure patient safety.[6,8]

Safe product holding begins at the point of receiving and continues throughout the patient's hospital stay. Consider the following based on the product used:

- For most infants, the parent's own expressed milk is the preferred feeding option; however, its internal integrity can be affected by how the milk is expressed, stored at home, and transported to the health care unit.[9] Families may have limited prior experience with HM handling, and they often receive education while the parent is physically recovering from birth and managing the emotional stress of a hospitalized newborn. Risks increase when a parent's own milk is mislabeled, including when labels are missing, illegible, or incorrectly belong to another patient. This is particularly important to note when there are language barriers or limited reading proficiency.
- When handling DHM, key safety considerations include a thorough understanding of donor screening, milk testing, and heat processing methods.[9,10]
- Regarding formula, it is important to understand the availability of sterile products, such as ready-to-feed or concentrated liquid formula, and the contamination risks associated with nonsterile feedings, including powdered products and blenderized tube feedings.[5,11,12]
- Fortifiers, additives, and supplements used for infants and pediatric patients may be manufactured from DHM, commercial formula, or whole foods.
- The water supply used for enteral feedings in hospitalized patients must also be considered to ensure that it is not a source of contamination.

Careful monitoring of inventory levels, expiration dates, and holding practices for feeding products ensures a consistent and safe supply for hospitalized patients.[6]

To prepare appropriate feedings, health care workers benefit from a clear understanding of each product's intended use. This includes recognizing what does and does not constitute a contraindication to the use of HM, as well as understanding whether their facility requires consent or assent or follows a standard-of-care approach for the provision of DHM or infant formula. Familiarity with institutional protocols for requests involving informally shared HM and nonformulary products (eg, imported infant formulas and blenderized tube feedings) is also important. Knowledge of the appropriate use of specialized products, such as preterm fortifiers or metabolic formulas, supports

alignment of product selection with the patient's nutrition and medical needs. Additional considerations may include potential allergens, the need for thickened feedings, palatability, patient preferences, and cost.

Finally, health care workers benefit from familiarity with product composition to support proper use. Feedings must be prepared using the correct base product, appropriate additives, and accurate recipes to achieve a safe concentration and osmolality. Using appropriate supplies for the storage of expressed HM and prepared feedings is also important. Storage containers must be food-grade, appropriately sized, capable of accurate measurement, and individually packaged for single use when possible. Awareness of variability in HM composition, measurement increments, volume displacement, and recipe ratios supports preparation accuracy. Clear labeling of products with contents and expiration times further promotes safe preparation and administration.

Environment (E) Risk

The third element of the PPE framework is environment, which focuses on the physical space where feedings are handled. Protecting the *external integrity* of products is an important consideration throughout this process. Every physical touchpoint—from preparation surfaces to delivery carts to bedside tables—can introduce opportunities for cross-contamination. Individuals working in health care settings may face added challenges related to time constraints, limited space, and communication demands.[10] Staff are often required to work efficiently while continuing to uphold food safety standards, even during periods of high volume or when workflows are unexpectedly delayed.

Leaders of feeding preparation operations play an important role in supporting appropriate planning, oversight, and staffing. Workspaces benefit from having proper equipment and access to clean and operational items such as a handwashing sink, refrigeration units, and dry storage. Thoughtful workflow design can help reduce foot traffic and interruptions during mixing, thereby lowering the risk of cross-contamination and errors. These principles often can be addressed without major renovations; straightforward steps, such as reorganizing supplies or establishing clear traffic patterns, can meaningfully improve workflow safety. Attention to ergonomics is also valuable in feeding preparation spaces and can be supported through small changes, such as the addition of antifatigue mats, to support staff comfort and safety.

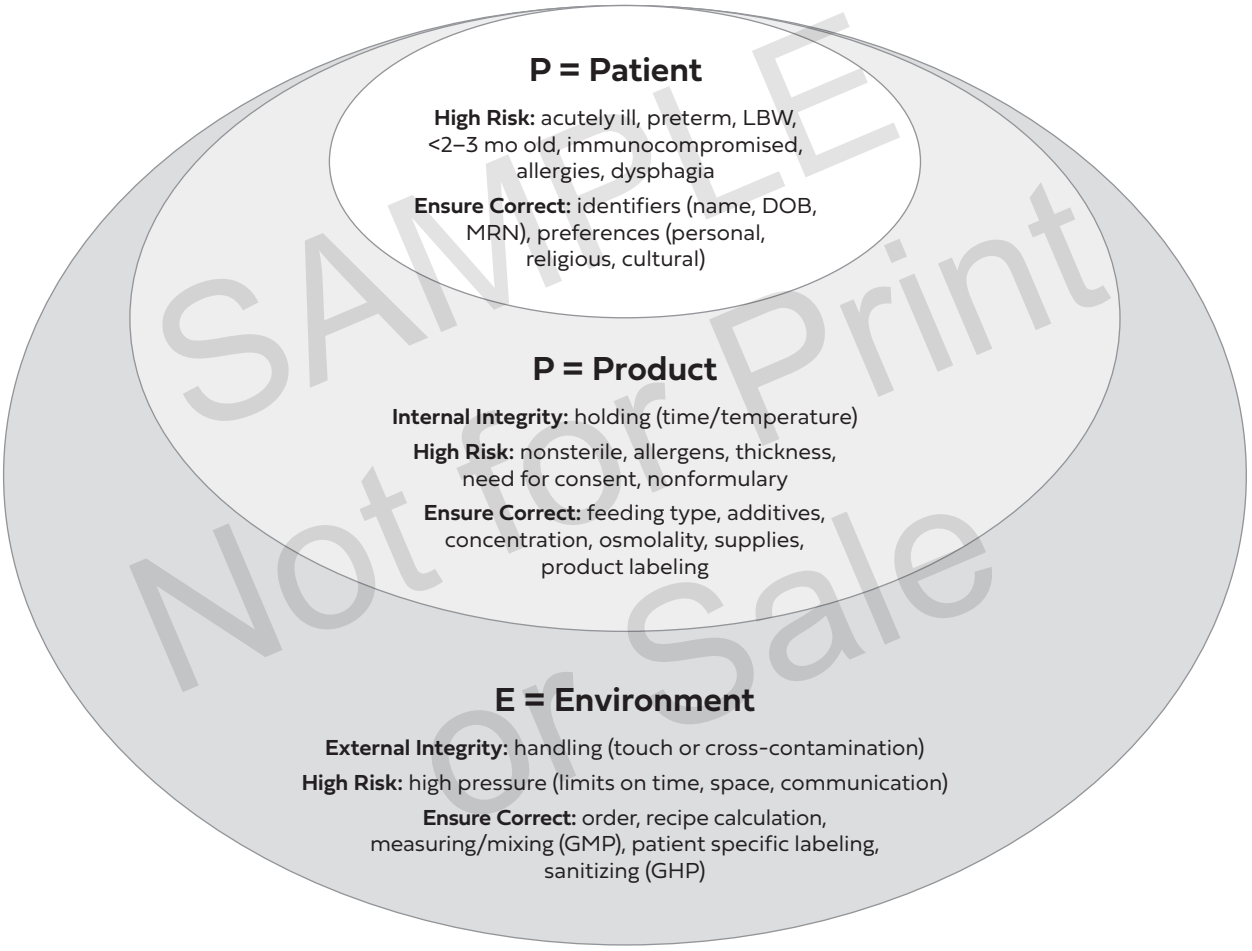
Staff who have appropriate qualifications and are trained in accurate feeding preparation contribute to a strong culture of safety. Adequate staffing ratios help support not only feeding preparation but also essential room management tasks such as inventory, supply ordering, stock rotation, cleaning, and required documentation. Maintaining tidy, clean, and sanitized workspaces supports efficiency, as does clear, precise communication to reduce confusion.[10] Errors are more likely when orders are rushed or unclear, highlighting the value of standardized feeding protocols, clear order sentences, and order verification, especially when feeding plans may change after procedures or with direct breastfeeding. Staff proficiency in calculating feeding volumes and preparing recipes in accordance with good manufacturing practices across all stages of handling further supports safety. These practices include standardized processes, ingredient verification, and consistent handling protocols to help reduce errors and maintain safe feeding preparation.

After preparation, attention to accurate labeling, safe storage, and correct delivery of feedings helps support safe administration, including the use of patient-specific identifiers

when appropriate.[13] Maintaining cleanliness and proper sanitizing practices in the feeding preparation area reflects strong hygiene standards, including hand hygiene, surface sanitation, equipment cleaning, and separation of clean and dirty tasks to reduce the risk of cross-contamination. In health care settings, single-use feeding equipment is often preferred to help lower infection risk, as reuse of storage and preparation bottles has been associated with outbreaks.[14] Ongoing attention to handling touchpoints within the environment, along with continued staff education, plays an important role in preserving the external integrity and safety of prepared feedings.

The PPE framework is summarized in Figure 1.2.

Figure 1.2 Reimagining PPE as a framework for identifying food safety risk



Abbreviations: DOB, date of birth; GHP, good hygiene practices; GMP, good manufacturing practices; LBW, low birth weight; MRN, medical record number; PPE patient, product, environment.

MANAGING FOOD SAFETY RISK

Identifying risks in pediatric feeding preparation spaces is the first step in managing food safety risk. The PPE framework provides a flexible and responsive approach to assessing food safety risks in real time. This patient-centered framework supports decision-making at the point of care, particularly when workflows shift or patient needs change

rapidly. In contrast, the hazard analysis and critical control point (HACCP) system provides a structured, linear method for identifying and managing risks at defined control points in the food preparation process.[15] Originally developed for foodservice operations, HACCP remains foundational for proactive planning, regulatory compliance, and system-wide quality assurance. When used together, the PPE framework and HACCP system provide a comprehensive safety strategy that supports both point-of-care responsiveness and long-term food safety planning and monitoring.

Despite the use of technology to help with electronic order entry, recipe calculations, expiration tracking, and patient identification scanning, the risks of foodborne illness remain significant.[16,17] Technology improves accuracy, efficiency, and tracking, but it cannot replace the need for strong food safety practices. Regardless of available resources, health care operations must maintain a consistent focus on established food safety principles to protect patients. During challenges such as supply chain disruptions or product recalls, these practices help ensure that feedings remain safe and accessible. Food safety also supports flexibility in product use, which is especially important in pediatric care, where feedings often depend on a combination of specialized nutrition products and supplies to meet individual needs.[18] In this context, food safety is the foundation of food security by ensuring the continued availability of nutrition for pediatric patients who rely on it.

When staff understand how their practices may contribute to foodborne illness, they can better prioritize safety interventions. While food handler illness is a known safety risk, a greater concern is presenteeism (working while symptomatic). In health care settings, presenteeism occurs more frequently than absenteeism, with one study showing that over half of health care workers reported working while ill.[19] Although respiratory viral shedding was detected on only 0.3% of study days, food handler illness may contribute to up to 67% of foodborne illness cases, especially when gastrointestinal symptoms are present.[19,20] These findings emphasize the need to facilitate honest communication about symptoms, ensure appropriate coverage for essential tasks, and follow return-to-work protocols after illness.

While holding errors related to time and temperature control are strongly associated with illness, handling errors related to touch and cross-contamination carry the highest risk.[21] These errors more consistently lead to poor outcomes likely because they occur more frequently. Although most staff comply with gown and glove use, jewelry remains a frequent source of contamination risk. Improper hand hygiene, even among well-intentioned staff, can also lead to cross-contamination, especially when poor organization leads to more touch points.[22]

Food safety cannot be an afterthought. Safe handling practices must be intentional and built into the workflow, similar to how a chef uses *mise en place* to organize and prepare the workspace for safe, efficient food production.

Instilling the importance of food safety concepts can be transformative for staff, especially when using a variety of learning modalities.[23] Education for health care staff should be quick, accessible, and directly related to specific feeding preparation space policies.[20] Leaders can provide clear and open communication with easy-to-use tools that reinforce essential practices. Building a culture that prioritizes proper food safety practices is critical to the success and mission of the infant and pediatric feeding preparation space.

KNOWLEDGE AWARENESS PRACTICE MODEL FOR PRACTICE CHANGE

Leaders who develop a comprehensive understanding of food safety practices and educate staff on the guidelines presented in this book have taken the first steps in creating a strong feeding preparation workflow. The next step is to ensure that knowledge translates into consistent compliance with food safety practices. To achieve this, it is necessary to understand how knowledge, awareness, and practices (KAP) interact to drive behavior change. The KAP model is commonly used in health care and safety contexts.[21] Many of the studies referenced in this section were conducted in general food handling environments but offer important insights that can apply to the health care setting.

Knowledge (K)

A thorough knowledge of food safety practices alone does not guarantee that safe practices are carried over into the workplace. While a person's education level and food safety proficiency can support understanding of food management systems and procedures, it is not a direct predictor of safe food handling practices.[22] Prior food handling experience may support, be neutral toward, or even hinder adherence to safe food handling practices.[21] Staff may hold preexisting biases from food handling experiences that conflict with current guidelines.[21,22] When staff rely on previous habits without critically evaluating them, biases can form that create resistance to change, even when new evidence or guidelines demonstrate safer or more effective practices. Without recognizing this tendency, individuals may unknowingly continue unsafe behaviors simply because they feel familiar or have not yet led to an obvious negative outcome. The following are examples of how biases can create risks:

- Staff may understand expiration dates but incorrectly believe that spoiled food can always be detected by sight or smell, which is a common misconception.[20,22] This conflicting belief can lead to ignoring expiration dates, creating a risk of using unsafe products.
- Staff may know which pediatric feedings are not sterile but incorrectly believe that warm temperature deviations have no impact on microbial content (eg, when waiting to check in fresh milk, thawing frozen milk, or delivering prepared feedings to the unit).[20] This misunderstanding can result in complacency with regard to holding times and storage practices, underestimating microbial growth risks after warming.
- Staff may recognize the need for clean preparation areas but may not fully understand the importance of using appropriate sanitizing agents, correct solution concentrations, and proper contact times.[20] This creates a gap where surfaces appear clean but may still pose a microbial contamination risk.

Even when staff receive additional education regarding food safety practices, improvement in practice does not always occur. However, meaningful change in food safety knowledge is often seen *after* an incident occurs.[22] This teaching concept can be applied by involving staff in incident reviews or incorporating case studies into education sessions.[22] Education can also focus on microorganisms of particular concern in pediatric feeding, such as *Cronobacter* bacteria, *Salmonella* bacteria, or methicillin-resistant *Staphylococcus aureus*.[20] Knowledge can be assessed in a variety of ways, with one of the most common methods being true/false assessment questions.

Awareness (A)

The A in the KAP model is commonly referred to as either attitude, ambivalence, or awareness. In this setting, *awareness* seems most appropriate because it focuses on raising understanding in a proactive way. Improving awareness requires recognizing that absence of harm does not mean absence of risk.[16,17,21] In the context of food safety, awareness includes recognizing when risks are present, one's own vulnerability to errors, and a patient's vulnerability to unfavorable outcomes. Even in well-resourced environments like hospitals, foodborne illness risks persist. Although hospitals, schools, and restaurants often perform well in food safety practices, hospital feedings are not free of microorganisms.[23] High inspection scores do not always indicate safer food and can sometimes create a false sense of security. In fact, increased food safety knowledge may unintentionally heighten optimistic bias, reinforcing the belief that problems are unlikely to occur.[21,23]

It is essential for leaders to target awareness of risks and biases to obtain staff buy-in and engagement with food safety practices. Awareness is shaped not only by training but also by internal judgments and external working conditions. Individuals may underestimate the likelihood of harm in familiar situations or rely too heavily on personal routines. These habits reduce attentiveness to critical safety practices. Staff may underestimate risk, overestimate control, and externalize blame when something does go wrong.[16,17] These biases often operate quietly and are reinforced by personal routines, time pressures, or assumptions of safety when outcomes have historically been favorable. Risk perception can also diminish during low workload periods such as weekends, holidays, or when working with trusted coworkers.[16,17] Even in highly regulated environments, skipping steps or extending holding times may seem harmless; in pediatric health care settings, small deviations in food safety practices can have serious consequences. Common biases include the following:

- Optimistic bias: believing negative outcomes are less likely to happen to oneself than to others[16,17,21]
- Illusion of control: overestimating personal ability to prevent harm by relying on personal routines or shortcuts.[16,17,21]
- Low perception of risk: underestimating the likelihood or severity of food safety incidents[16-18]
- Lack of motivation: avoiding behavior change due to perceived effort, fatigue, or task overload[21]
- Blind spots: failure to recognize potential hazards due to assumptions, routine familiarity, or misplaced trust in systems or colleagues[16-18,21]

Measuring awareness is often generalized, so open-ended questions (ie, "Why is food safety an important part of your job?") can encourage reflection and deeper insight into exploring risk and biases.[24] Education can also address perceived probability and severity of risk using simple rating scales, with responses ranging from "none or very low" to "very high," supported by teaching incidence rates and outcomes.[18] Awareness tends to increase after incidents, which further supports involving staff in incident reviews and using real-life examples to guide learning.[22] For staff with less formal food handling experience, correlations may need to be made to familiar high-risk foods, such as sushi, egg salad, or raw cookie dough.[23]

Strengthening awareness of risk and bias helps bridge the gap between knowledge and consistent safe practices. Scenarios like those provided here can be used to promote reflection and encourage staff to recognize the importance of food safety in their daily workflow decisions[23]:

- General food handling risk—What is the probability of experiencing a foodborne illness (ie, abdominal pain and/or vomiting) after eating raw food (eg, sushi, tuna/egg salad, raw cookie dough, salad with sprouts) that has been:
  - prepared and stored in a home refrigerator for 1 day?
  - brought to the hospital and stored in the unit refrigerator for 1 day?
  - placed in the unit freezer for 3 to 6 weeks?
  - thawed and stored in the break room refrigerator for 20 hours?
  - left out on the break room table up to 1 hour before eating?
- Feeding preparation risk—What is the probability of a patient (preterm infant) having feeding intolerance (ie, abdominal distention, spits/emesis, or loose/bloody stools) when feedings are:
  - stored in the refrigerator for too long (time)?
  - overwarmed during thawing (temperature)?
  - stored on the countertop for too long (time and temperature)?
  - exposed to cross-contamination from high-touch surfaces like cabinet handles or computer keyboards (touch)?
- Food handler risk—What is the probability of a patient (preterm infant) having feeding intolerance (ie, abdominal distention, spits/emesis, or loose/bloody stools) after a feeding is prepared by:
  - you or someone you supervise (own risk, blind spot: good intent)?
  - a coworker in your unit (coworker risk, blind spot: workflow process)?
  - a technician with similar training who works in another hospital (peer risk, blind spot: unit safeguards)?
- Severity of outcomes—If a patient (preterm infant) receives a contaminated or spoiled feeding, what is the likelihood that a foodborne illness or gastrointestinal intolerance could be serious or life-threatening (ie, sepsis workup, necrotizing enterocolitis)?

Practice (P)

In the KAP model, practice refers to the actual behaviors, routines, and decisions made while holding and handling pediatric feedings. These actions may align with institutional guidelines or personal knowledge. Practice is the most critical outcome of knowledge and awareness but also the most variable, as what staff report doing is not always what is observed. In nearly 50% of food handling studies (17 of 36), knowledge and/or awareness did not consistently lead to safer practices.[24] This highlights a persistent challenge in food safety: the critical gap between knowing what to do, understanding why it matters, and consistently applying that knowledge in real-life settings. Despite understanding protocols and recognizing risks, staff may still deviate from best practices due to competing demands, habitual routines, or environmental pressures.

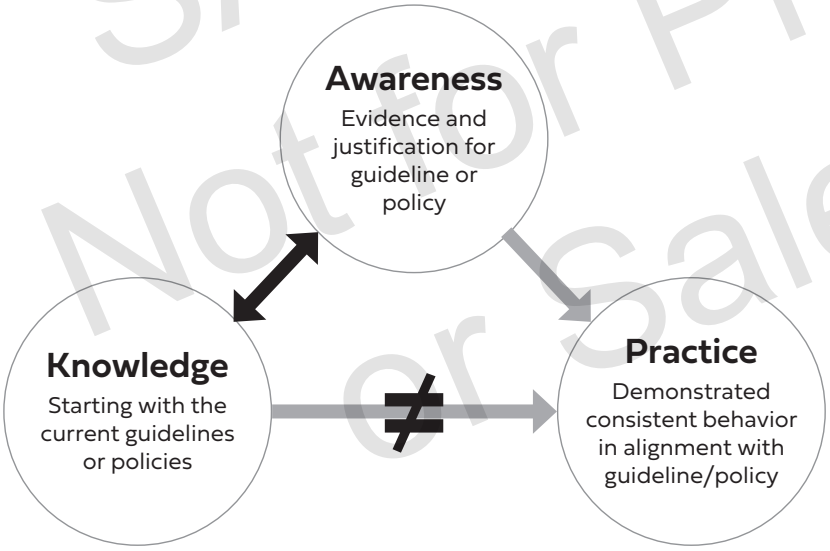
Self-reported practices can offer insight into general trends but often overestimate actual compliance. Staff may report that they "always" sanitize surfaces, maintain

appropriate temperatures, or follow holding times, yet real-time behaviors may differ. These self-reported practices can be assessed using a frequency scale such as *never, rarely, sometimes, often,* or *always* to help identify patterns and guide targeted training.[18] Direct observation, however, provides a more accurate picture of practices. Observations often reveal missed steps or shortcuts, particularly in fast-paced or high-pressure environments.[18,24] To reduce the influence of being observed, a 30-minute washout period allows staff time to acclimate before documentation begins, increasing the likelihood of capturing typical behavior.[25] Some inconsistent or unsafe practices may remain hidden unless observers blend into the work environment and look beyond checklists. Combining self-assessment with structured, unobtrusive observation remains the most practical and effective strategy for evaluating and improving food safety practices.

While the KAP model is not without limitations (because real-world environments are more complex than the model implies), it remains a valuable tool for approaching food safety education.[25] It can guide initial assessments and support targeted improvements by helping teams reflect on how their knowledge and intentions translate into everyday practices.

Figure 1.3 provides a summary of how the KAP model can apply to managing feeding preparation practices and what biases may stand in the way of practice change.[21,25]

Figure 1.3 KAP model: when knowledge does not lead to practice change, address awareness and biases in food safety[21,25]



Common Biases

Optimistic bias: "I'm careful so there won't be issues"
Illusion of control: "I always do it this way to get done in time"
Low perception of risk: "Issues aren't likely to happen"
Lack of motivation: "I'm too busy to change right now"
Blind spots: "It doesn't usually happen that way"

BUILDING A CULTURE OF FOOD SAFETY

Developing a sustainable food safety culture requires leadership support and a collective commitment from all staff. Food safety culture is shaped by leadership behavior, clear communication, and consistent organizational expectations. It is a shared responsibility across teams, not the responsibility of one individual.[16,17] Core principles include:

- clarity—we communicate expectations and procedures in a way that is easy to understand and apply;
- consistency—we follow safe food handling practices every time, not just when it is convenient;
- correctness—we do things the right way, using evidence-based protocols to guide our actions; and
- collaboration—we engage in open dialogue to learn from one another and improve together.

Transformational leadership is key to building and maintaining a culture of food safety. Leaders who model safe practices, ensure access to training and resources, foster staff engagement, and communicate a clear vision help promote accountability and trust among the team.[16,17] These actions reinforce the link between food safety and patient outcomes. A strong food safety culture includes science-based decision-making, standardized training, and structured communication. This approach helps teams maintain high standards, respond proactively to challenges, and apply food safety practices consistently across all feeding preparation settings.

CALL TO ACTION

Optimize Your Preparation Spaces

Infant and pediatric feeding preparation spaces vary widely across institutions. Some are highly centralized with specialized equipment and dedicated staff, while others operate in noncentralized settings with limited resources and fewer personnel. Embracing this diversity while focusing on continuous improvement for each individualized unit is key to improving outcomes. Every step toward improving food safety practices matters. Consider the following:

- What are some quick wins or easy-to-accomplish goals your unit can achieve to improve food safety practices?
- What long-term changes are important for the future?
- What obstacles might make those changes difficult to implement?
- How can you create a plan to overcome those challenges and improve patient care?

Food Safety Principles Always Matter

Policies must be customized while remaining adaptable enough to uphold food safety principles across various settings, especially because workspaces and workflows can change over time. Food safety often gets attention during training, audits, or inspections, but a strong food safety culture carries practices forward even when no one is watching. As a complement to established food safety systems such as HACCP, the PPE framework

and the KAP model can be used to strengthen risk assessment, implement practice changes, and protect patients in real-world environments. This is especially important in pediatric health care settings, including NICUs and PICUs, where small missteps can have serious consequences.

The Heart of Food Safety Is Care

Every improvement you make in your pediatric feeding preparation workspace or workflow is a direct investment in the health and safety of the vulnerable patients and families you serve. All patients within a health care setting, regardless of their size, require nourishing food; prioritizing safe food handling practices is therefore an important focus for patient-centered care. These basic principles are the cornerstone for creating a robust and safe food preparation space. All members of the health care team should be invested in these food safety practices to ensure that the best care is provided to the patient.

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